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ABSTRACT

A report of a National Science Foundation (NSF) Workshop highlights the thoughts of a group of experts on the basic underlying principles of technology use in education, goals for integrating technology into the educational system, and methods for further enhancing the quality of education through technology use. The workshop provided an open forum for a group of 50 individuals with different perspectives to address strategies and define the next steps for technology use in education with an overall focus on the issues of culture change in schooling. The report is broken into three parts: underlying principles, goals, and next steps. Principles that underlie effective and appropriate technology use in education include the following topics: curriculum integration; educational reform; models of the role of technology; financing technology; the role of teachers; learning outside of school; leadership; access to information; technology as a tool for inclusion; technology policy; and cooperation between the public and private sectors. Goals based on the underlying principles highlight the following: full participation in the global interactive community; a set of common tools and modes of technology; self-sustaining mechanisms for continuing collaboration between educators and the community; incentives for developmental support; modified restrictions; and change in educational budget policy. A set of next steps are provided, based on the underlying principles and goals. An outline of an appendix available separately from NSF is provided. (AEF)

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Learning And Technology In The Future

A National Science Foundation Workshop
October 4–6, 1993

Directorate for Education and Human Resources
National Science Foundation

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Any opinions, findings, conclusions, or recommendations expressed in this report are those of the workshop participants and do not necessarily reflect the views of the National Science Foundation.

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Report of an NSF Workshop: Learning and Technology in the Future

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Introduction

This is a report of the workshop hosted by the National Science Foundation during October 4-6, 1993, at the Georgetown University Conference Center in Washington, D.C. The workshop was a follow-up to the National Academy of Sciences (NAS) Convocation "Reinventing Schools—the Future is Now" held earlier in the year. The NAS Convocation highlighted the differences between the technology available to young people outside of school and the technology available to students in schools. The NSF Workshop provided an open forum for a group of 50 individuals with different perspectives (private sector, classroom, education researcher) to address strategies and define next steps on technology usage in education. Individuals from the National Science Foundation, the Department of Education, the Department of Energy, and the NAS chaired discussion sections.

The objective of this report is to provide to the field the thoughts of a group of experts on the basic underlying principles of technology use in education, goals for integrating technology into the educational system, and methods of further enhancing the quality of education through technology use. The report is their advice to the field and to themselves, and we hope it will lead to specific action plans and proposals—by participants in the workshop and by readers of this report.

The groundwork for the workshop was laid by the participants, who prepared lists of key issues that should be addressed and examples of effective uses of technology that are in place or under development. These issues provided the backdrop for small breakout discussion sessions, which provided a forum for sharing of information, insights, and strategies; a thoughtful critique of current activities in the field; a look to what might happen in the future; and a definition of appropriate steps that need to be taken for technology to be effectively used in educational settings.

> *" 'Most of the students are learning things that they never would have experienced without the Science-By-Electronic-Mail project.' In some schools the students would purposely miss the bus home so they could stay and work on the system, and in others, the students would arrive at six in the morning to use the Internet."* [1]

The participants' variety of expertise provided an opportunity for sharing outside the usual colleague groupings and permitted participants to explore each other's needs, constraints, and barriers for the development and adoption of innovative technology in education.

This report does not address all issues in technology and education reform. School administration, for example, is not included, nor is its role addressed. Rather, the group focused its thinking on the overall

issues of culture change in schooling. An effort was made to consider both short-term steps and long-term goals; to think beyond what teachers would like to have now in the classroom; what the opportunities are for the future; and to determine the immediate steps that should be taken to ensure that these opportunities are addressed in a timely fashion.

The report that follows is broken into three parts: Underlying Principles, Goals, and Next Steps. These three main divisions were drawn from and reflect the group's discussions.

The report is presented in an outline format so that the individual principles, goals, and next steps are clearly delineated. The appendices present additional information, including a summary of each discussion group's report, and the lists of issues prepared and defined by the participants. The agenda for the workshop and a list of participants are included with the Appendix materials. Appreciation is expressed to those who read advanced, electronic copies of the report and contributed to its editorial development.

It is the hope of the organizers that this information will be useful to those planning activities and programs related to the uses of technology in education. It is clear that the next steps recommended by the group must be implemented by a variety of individuals and organizations, and it is hoped that this report will lead to strategies and activities that will make it possible for these steps to take place.

Underlying Principles

The workshop identified a set of principles that underlies effective and appropriate technology utilization in education. These principles frame different and necessary elements of successful technology utilization in support of education and of education reform.

Integration:

1. Technology is part of society and should be tightly interwoven into education through curricula.

"At my school right now there are not many girls who are interested in network technology as I am, though there are quite a few boys. By joining a listserv called Kidcafe, I have met a group of girls who are just as interested as I am....Once in a while, we discuss how few girls at our schools seem to be interested in the network. Sometimes we help each other learn how to do new technical things."
—Rachel Weston [2]

- Technology is a neutral tool; technology integrated into the curriculum and educational progress go hand-in-hand.
- Technology provides educators with new and varied instructional opportunities, including topics that were impossible to teach without technology.
- Learning, the basic business of schools, should be engaging for teachers and students. Technology can help achieve this engagement.
- Technology can enhance the educational process without eliminating valuable, traditional learning approaches and methods.

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2. Educational reform must involve the entire educational community and increase not only the quality of education but the productivity of and communication among its members (e.g., students, teachers, administrators, parents, school board members, teacher preparation program faculty).

- Educational reform is an ongoing process, not an ideal end-state or product.
- Educational reform must be integrated with the technological and social requirements of modern society.
- Strategies and procedures to increase interactions between the community and all members of the educational system need to be developed.

3. Models and exemplars of the role that technology can play in educational practice are needed in order for schools to adopt and adapt appropriate practices; their distribution should take advantage of the technology and model its use.

- Alternative models of instruction must be available to teachers so they can explore new options for teaching and learning.
- Diverse models, appropriate for a variety of educational settings and local communities (e.g., rural, suburban, and urban) should be provided to support a range of learning communities.
- Models must demonstrate an acceptance of the diversity of the human experience with regard to race, gender, ethnicity, and learning styles.
- Clusters of schools should be encouraged to work together and with others, such as the private sector and educational researchers, to implement models and exemplars, to be model sites for other schools, and to be proactive in making their experience available to educators by a variety of means.

> *"Teaching is a solitary profession. I am in the classroom all day with a short break at lunch. Time to discuss ideas with others in my area of interest is rare, and, since I am an expert in a particular field in a smallish school district, there is no one who actually understands what my concerns are or what my curriculum entails most of the time. Telecommunications has provided me with the opportunity to enter discussions with other teachers with similar concerns. Access to information allows teachers to be independent researchers and learners."*—Jan Mezel, High School Teacher [3]

4. The financing of technology must be built into the ongoing school and district base budget and not be considered an add-on. It must include training, service, maintenance, amortization, and timely replacement.

- Leaders in budget policy-making need to plan for some technology that is short term and expendable, as well as technology that is long term.
- Costs of personnel, technical support, and training should be included along with the equipment cost.

People's Roles:

5. Teachers as professionals (i.e., as educators, mentors, learners, facilitators, leaders, curriculum developers, etc.) are critical to the long-term success of any innovation.

- Technology can help teachers use their time more productively, thus supporting their efforts in expanding their professional activities and in carrying out their central role in reform, in next-generation instruction, and in the formation of learning communities.
- Teachers work when and where they have time and resources, and this includes the home. They need a computer to take home to use for professional purposes, e.g., creating a multimedia presentation, linking with colleagues, using an electronic gradebook, continuing professional development.
- Teachers need scheduled time for planning, experimentation, collaboration, and staff development.
- Teachers should be recognized and receive credit for technological innovation in their classrooms.

6. Learning takes place in and out of school; contributions to the learning experience can be made by students, parents, and others in the community.

> *"The most useful feature of networking is communication. Probably one of the most frustrating features of being a part of a larger education group is not knowing what is going on. Those who know seem to assume the rest of us also know....when we don't because we haven't been told. If we ask, we sometimes feel that others think we are 'nosy' rather than concerned."*—Betty Dawn Hamilton, School Librarian [4]

- Everyone can be a teacher and a learner; contributions by students, parents, and other community leaders are important. Students must be "met on their own turf," using the media they find attractive, in an environment that will engage them.
- Educational applications should be developed to take advantage of the widespread ownership of personal technology, such as home video games, and help orient it toward educational, nonviolent, constructive ends.[1]
- Apprenticeships and mentoring can be used by members of the out-of-school community to facilitate the connection with students and teachers.

7. Change in the schools and in the education of teachers requires leadership; leadership for these changes can often be found in new places.

- Schools will not change until the culture of schooling changes.
- Teachers and others knowledgeable in technology are part of the source base for leadership (e.g., parents, the private sector, professionals in the community, students).

[1]Home video game ownership has already crossed social and economic boundaries: for teenagers ages 12 through 19 the percentage was 48.5 for whites, 56.1 for African-Americans, and 47.1 for Latinos (Teenage Research Unlimited, Teenage Marketing and Lifestyle Study, WAVE 20, Fall 1992).

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8. Technology, with ready access, will change who is in control of information within schools and classrooms.

- Technological tools that increase access to information will open up the curriculum and change the way we view content.
- Direct access to information and educational mentors at distant locations by means of technologies such as wide-area computer networks and satellites will change the teacher's role within the classroom and alter the school site administrator's role from authority figure and bureaucrat to that of learning facilitator/manager.
- The new responsibilities at the home, local, state, and Federal levels need to be confronted explicitly.

Serving National Goals:

9. Technology can, and must, be used as a tool for inclusion instead of exclusion.

- All learners in all learning environments should have equal access to the information, communications tools, and educational opportunities new technologies provide.
- Technology changes the definition of community: it becomes borderless and expands beyond the traditional neighborhood concept. We must build learning communities of interest that promote inclusion.
- Technology can provide opportunities for lifelong learning and can help address the specific educational needs of those outside of the system, such as dropouts, prisoners, and people continuing their education. Technologies can be democratizing: text-based conferencing masks many personal attributes, and network conferencing can admit equal access.
- The technology tools that are developed should be "transparent," easy to use, helpful in overcoming barriers to multicultural and multilingual interaction, and accessible to people with disabilities.

> *"I am totally blind; with two glass eyes. I have been blind all my life, and have never known anything different. I have been mainstreamed in schools all my life, and have always had to depend on others to get me school materials....Getting Internet access was the best thing that ever happened to me. In a way, my computer and access to the net has become my eyes to the world. I can read a newspaper, talk to people around the world, and get materials for class papers, unlike before when I had to depend on others to get the resources I needed."*—Randy Hammer [5]

10. Technology policy must promote the integration of educational technologies with the technologies outside of school.

- Federally funded projects should provide models of such technology.
- Scalability—the ability to start at any level and the ability to increase access and expertise—requires the development of standard tools, open architectures, and standard interfaces.

- Eliminate policies that prevent the development of reasonable technical infrastructures (i.e., single-source providers).
- Utilize outside groups that need networking connectivity (i.e., health care).

11. Educational reform is in the best interest of all segments of American society. Collaboration with the private sector is essential to its sustainability.

- Follow-on funding should be provided to support a research activity and its introduction into the commercial marketplace.
- Funding agencies should consider, from the earliest planning stages, possible technology transfer and the likely commercialization routes of the work in the event it is successful.
- Business and industry should view collaboration with schools as the process of building a human infrastructure, as well as an important marketing opportunity.
- Mechanisms need to be implemented to aggregate markets and provide managed risk for innovative technology. Cooperation between the public and private sectors is needed to achieve this. Private sector consortia, such as the Microelectronics and Computer Corporation (MCC), should be encouraged.

"A group of very excited teachers 'discovered' the net! These new ideas became the catalyst for some to rethink how they did things. I saw restructuring of education happening in the classroom as a result."—Patsy Lanclos, Master Trainer [6]

Goals

The workshop identified a set of goals, based on the agreed upon underlying principles. These goals are instantiations of the underlying principles, geared to the current status of the education community's understanding of and access to appropriate technology. These goals can be used to formulate and set directions for effective long-range flexible technology plans.

1. Provide for full participation in the global interactive electronic community.

Implications:

- More than access, full participation defined on the basis of individual and group needs.
- Multiple definitions of participation that address the needs of diverse communities and individuals.
- Consensus required on a minimum acceptable level of participation.

2. Adopt common tools and flexible modes of technology use for learning and discovery; these tools should facilitate the development of learner expertise and integration with the world outside the school.

Implications:

- Develop empowering tools, as well as specific technology-based materials.
- Develop flexible standards and protocols—and common libraries of software that implement them—and a cross-platform approach to infrastructure that can evolve and improve over time.

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3. Create self-sustaining mechanisms for continuing dialogue and collaboration between educators and other sectors of the general community.

Implications:

- Particularly significant to this goal are collaborations with parents, technology developers, and private sector producers of educational materials and services.
- We must help the educational and general communities to understand that technology implementation is a long-term process that brings with it changes in teaching and learning practices. Restructured schools and classrooms look and feel different from traditional ones, and parents may not recognize them as places where learning takes place.

4. Create incentives for continued support and development of a "culture of change and innovation" in schools.

Implications:

- Recognize and reward innovative teaching activities that technology makes possible.
- The most qualified educators using the latest techniques and content, through teaching practices that model innovation, should form the basis for teacher training and retraining. The educational community, appropriately reluctant to experiment with students on a large scale, can utilize the model of the "teaching hospital" to transfer learning from the most qualified, innovative teachers to the general community.

"Although we have intended all along to inform the district and the school board about what we are doing with our CO_2 studies, the faculty survey about air quality, and the results, we hadn't done so yet. However, four men from the environmental control section of the district showed up at our door-step Friday morning. They first went into the counseling office where the counselors and teachers told them about what was going on. They were not impressed, so they were brought to my classroom. As soon as we pulled out the data, and the graphs showing the patterns that we had found they suddenly started to take notes."
—Linda Maston [7]

5. Make regulations (local, state, Federal) less restrictive, and modify funding regulations that impede the integration of technology into the educational system.

Implications:

- Market and regulatory barriers must be removed to allow for an exploration of all educational options, to lower the risk for product introduction and school innovation, and to redefine the role of the private sector in supporting long-term change and reform.
- Develop appropriate technology goals and change those regulations and organization structures that are barriers to achieving these goals (for example, by providing funding for technology in Federal grants and by allowing tax credit for teachers who purchase equipment for home use).

"Through the Internet, my ninth-grade biology students are receiving information from scientists involved in a trek across part of northern Canada. As they travel, the scientists send information about their geographic position, the weather, and animal life. They document their feelings about their journey and share these thoughts with the students. Students then chart the scientists' positions on a map and log in relevant statistics." [8]

6. Effect change in educational budget policy that will support the culture of change.

Implications:

- Allow for low-cost entry and provide a clear path for growth.
- Schools should not personally bear the burden of international competitiveness and national needs; we need mechanisms to support their purchase of equipment and software and provide them with appropriate financing that covers training and time to incorporate technology in the curriculum.

Next Steps

The workshop identified a set of next steps to take, based on the agreed upon underlying principles and goals. The community at large must seek support from all sectors and design activities to implement these next steps. These steps are not admonitions for others but proposed actions for the educational community itself to undertake. Federal agencies and the commercial sector must be proactive in their interaction with the education community.

1. Define "full participation" by its expected outcomes.

    - The Federal agencies involved should fund a multistakeholder group to look at basic common modes of technology use for education, such as empowering tools, shared general functions, and applications.

2. If the National Education Goals are to be achieved by the year 2000, timely access to implement full participation, including home, school library, and community access, is a must—we suggest the following:

    - Electronic links to every school should be in place by FY 1996. Electronic links to every classroom should be in place by FY 1998. Student clusters in every classroom should be in place by FY 2000.

3. We must have in place self-sustaining mechanisms and a starting set of related materials that support:

    - The dissemination of practical information and models to the citizenry, parents, school boards, schools, teachers, and students. Collaborations among private sector, education researchers, curriculum developers, classroom teachers, and nonprofit centers—such as

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museums and libraries—to reduce developer risk and aggregate educational markets for innovative, interdisciplinary materials.

4. The participating agencies will articulate a shared strategy for addressing implementation and policy issues, such as financing, telecommunication costs, intellectual property rights, and agency regulations that impede the integration of appropriate technologies in education.

5. The participating agencies will have established an ongoing system of rewards and recognition for existing, innovative technology applications in the classroom and in teacher education and enhancement. This system will encourage master teachers and their schools to disseminate their strategies and act as models. The first round should be awarded by FY 1995.

6. The National Science Foundation and the Department of Education will have in place a strategy and funding for furthering the work of the mathematics and science standards groups (for curriculum, teacher preparation, and assessment) to incorporate a proper role for technology.

Endnotes

1. *51 Reasons: How We Use the Internet and What it Says About the Information Superhighway*, page 101.

2. One of a number of winning student essays on the topic "Networks: Where have you been all my life?" submitted as part of a NASA/Department of Education/NSF invitational conference.

3. *Building Consensus/Building Models: A Networking Strategy for Change*, page 14.

4. *Building Consensus/Building Models: A Networking Strategy for Change*, page 16.

5. One of a number of winning student essays on the topic "Networks: Where have you been all my life?" submitted as part of a NASA/Department of Education/NSF invitational conference.

6. *Building Consensus/Building Models: A Networking Strategy for Change*, page 24.

7. *Hands On! Hands-on Math and Science Learning*, Vol. 16, No.2, page 1.

8. *51 Reasons: How We Use the Internet and What it Says About the Information Superhighway*, page 75.

References

1. *Building Consensus/Building Models: A Networking Strategy for Change*; (Published by Federation of American Research Networks, Inc., Consortium for School Networking, March 1994.) Supported by NSF under Grant No. RED-9254947.

2. Martha Stone-Martin and Laura Breeden, Eds, *51 Reasons: How We Use the Internet and What it Says About the Information Superhighway*, (Lexington, MA: FARNET, Inc., 1994).

3. Winning student essays on the topic "Networks: Where have you been all my life?" submitted as part of a NASA/Department of Education/NSF invitational conference held in Orlando, FL, on February 24–25, 1994. The winning essays are available on the Internet via gopher at quest.arc.nasa.gov, under the contest title. A sampling of the essays will be published in late 1994.

4. Boris Berenfeld, *Hands On! Hands-on math and science learning*, (TERC Communications, Cambridge, MA: 1994), Volume 16, No. 2.

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